Single Top CSC Note status report

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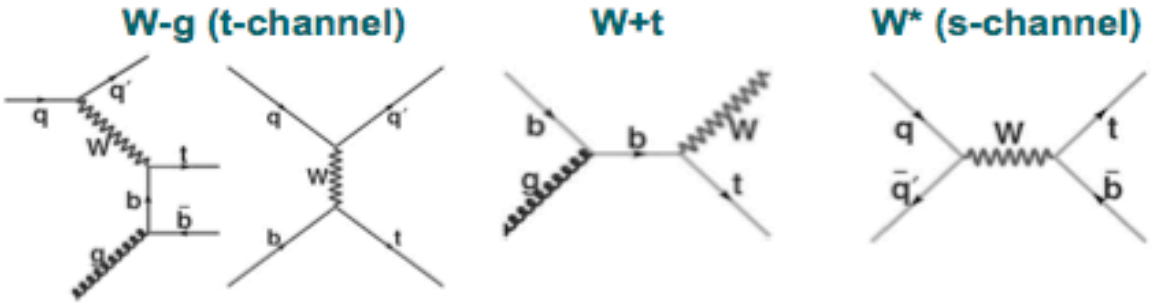
Talk Outline

- Single Top at LHC
- CSC note contributors and synopsis
- MC samples
  - Validation
  - Reconstruction Performances
  - LAr bug effect
- Trigger Studies
- b-tagging Studies
- Individual Analysis Status
- Conclusions

Single Top Production at LHC



Properties of the Wtb vertex :

- Determination of $\sigma(pp \to tX)$, $\Gamma(t \to Wb)$
- Direct determination of $|V_{tb}|$
- Top polarization

- **Precision measurements → probe to new physics**
  - Anomalous couplings
  - FCNC
  - Extra gauge-bosons W′ (GUT, KK)
  - Extra Higgs boson (2HDM)

t-channel,Wt

s-channel

~2×10^6 events/yr in low luminosity runs

- **Single-top is one of the main background to …**

… Higgs physics…

M(top) = 175 GeV/c^2		s-channel	t-channel	Associated tW	Combined (s+t)
TeVatron σ_{NLO}		0.88 ± 0.11 pb	1.98 ± 0.25 pb	0.1 pb	
LHC σ_{NLO}		10.6 ± 1.1 pb	247 ± 25 pb	$62\ ^{+17}_{-4}$ pb	
Run II 95% CL	CDF	<3.2 pb	< 3.1pb	NA	< 3.5
	D0	4.6-5.0 ±1.4-1.9 pb		NA	4.6-5.0 ±1.4-1.9 pb

σ_{t+s} = 2.9 pb for m(top) = 175 GeV/c^2

Single Top Decay at LHC

Decay modes:

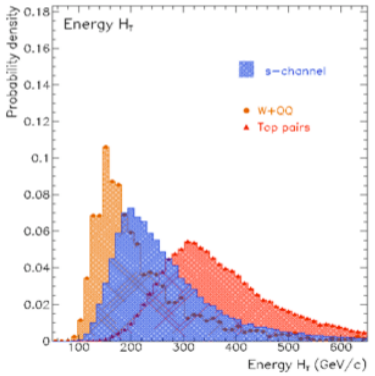
- W* : W* → t bbar → ($l^+\nu$b) bbar
- Wg: q'g → t q bbar → ($l^+\nu$b) q bbar
- W+t: bg → t W → ($l^+\nu$b) qq'

1 leptons + MET
+ ≥ 2 jets
+ 1(2) b-tags

Channel	σ x BR(pb)
W-g	54.2
W+t	17.8
W*	2.2
ttbar	246
Wbb	66.7
W+jets	3,850

Common selection for all 3 single-top samples :

- 1 High pT Lepton + mET
→ reduce non-W events
- At least two high-p_T jets
→ reduce W+jets events



- Single-top ~22-26%
- ttbar ~ 38%
- WQQ ~ 1.5% , W+njets < 1/1000

T8 Single Top Note

- Contributors
  - K. Assamagan (BNL)
  - M. Barisonzi (NIKHEF)
  - F. Chevallier, B. Clement, A. Lleres, A. Lucotte (LPSC/IN2P3)
  - M. Cobal (INFN)
  - C. Cojocaru, M. Khakzad (U. Carleton)
  - A. Shibata (Queen Mary, U. of London)
  - A. Di Mattia, B.G. Pope, P. Ryan, R. Shwienhorst (Michigan State U.)
  - S. Rolli (Tufts)
  - N. Triplett (Iowa State U.)
  - Editors: A. Lucotte, S. Rolli

https://twiki.cern.ch/twiki/bin/view/Atlas/TopGroupNoteT8SingleTop

Synopsis (preliminary)

- Introduction ... [Simona,Arnaud]
- I. Single-top Phenomenology [Arnaud,Reinhard] :
  - Single top cross-section
  - SM backgrounds
- II Single top pre-selection
- L1 Triggering ..... [Bernard,Reinhard,Patrick, Alessandro, others ?]
  - Inclusive lepton triggers
  - Jet triggers
  - Trigger efficiency & redundance
- Preselection ..... [All]
  - Lepton selection (in link with lepton perf. note)
    - Definition & reconstruction efficiency
    - Selection efficiency
  - Light jet selection [Mohsen,Claudiu, Akira, Marcello, others?]
    - Definition % recon efficiency : cone size studies (in link with jet perf. note)
    - Threshold optimization (non-top, top pair bckgds)
  - b-tagged jet selection ..... [Simona,Monica,Mohsen,Claudiu,Akira]
    - Definition % recon efficiency : cone size studies (in link with jet perf. note)
    - Threshold optimization (non-top, top pair bckgds) .
  - Missing ET
  - W-transverse mass and /or angular discriminating power [Reinhard, others?]
    - Definition
    - Performance
  - Leptonic top mass reconstruction ..... [Claudiu, Mohsen, Akira]
    - optimization of the neutrino solution
    - optimization in the M(lvb) reconstruction
    - Influence of jet cone algorithm & size

Synopsis (cont'd)

- III Single top cross-section measurements
  - Wg channel analysis
    - standard cut-based selection [Claudiu, Mohsen,Akira, Marcello]
    - NeuralNet? selection [Nathan]
    - systematics : [All the above]
    - b-tagging
    - Jet Energy scale
    - Gluon radiation Modeling
    - Forward jet reconstruction & b-tagging
  - Wt channel analysis ..... [Marina, Simona, Annick, others ?]
    - Selection & performance
    - systematics :
    - b-tagging
    - Jet Energy scale
    - Gluon radiation Modeling
  - W* channel analysis ..... [Arnaud, others?]
    - selection & performance
    - systematics :
    - b-tagging
    - Jet Energy scale
    - Gluon radiation Modeling
- IV. Interpretation : top width measurements ..... [Ketevi,others ?]
  - Selected samples
  - Performance and systematics
- V. Single top evidence with the early data ..... [Bernard, Reinhard,Patrick,Akira,Alessandro]
  - Triggering [Bernard, Reinhard, Patrick]
  - Selection
  - Influence of b-tagging performance
  - Background studies [Akira, Reinhard]
  - Combined Wg and other single top channels ? [Bernard, Reinhard, Patrick,Alessandro, ?]k,Alessandro, ?]

Several groups/people already active

- LPSC Grenoble
  - -ntupleMaker, common infrastructure,all channels
- Queen Mary/UL
  - -TopView common ntuples, t-channel
- Tufts
  - - btagging performance all channels
- Carleton University
  - -reco efficiency and purity of jets all channels
- Iowa State
  - NN t-channel analysis
- MSU
  - - trigger studies

MC sample status

- Signal:
  - Wt sample 5500
  - s-channel sample 5501
  - t-channel sample 5502
- Backgrounds
  - Top sample 5200/5204/5205 (Full Simulation)
  - W+jets :Alpgen+HERWIG (Fast Simulation)

- Most of the v12 samples were ready only in the past few weeks, although validation work has been going on the samples produced with previous releases

W+jets generation

Benoit Clement
Grenoble

- The samples generated for pair top analyses are inadequate for single top
  - 3 jets filtering with high P_T threshold
- Several filtering configurations ran (next page)

- It might be impossible to produce enough W+jets fullsim with low multiplicities.
- **Proposal:** as many of these events will be killed by tagging, one might choose not to tag the W+jets MC and weight the events by their tagging probability.
- The number of events needed would therefore be reduced by a factor equal to the mistag rate. Then 200k or 300k events could be enough. (note that, for other reasons, this weighting procedure as been extensively used at D0)

Filtering efficiency and Effective X-sections (LO)

At least 2 jets, lepton P_T>20 GeV, MET>15 GeV

jets P_T> 15 – 25 GeV Leading jet P_T(top) > 15 – 40 GeV

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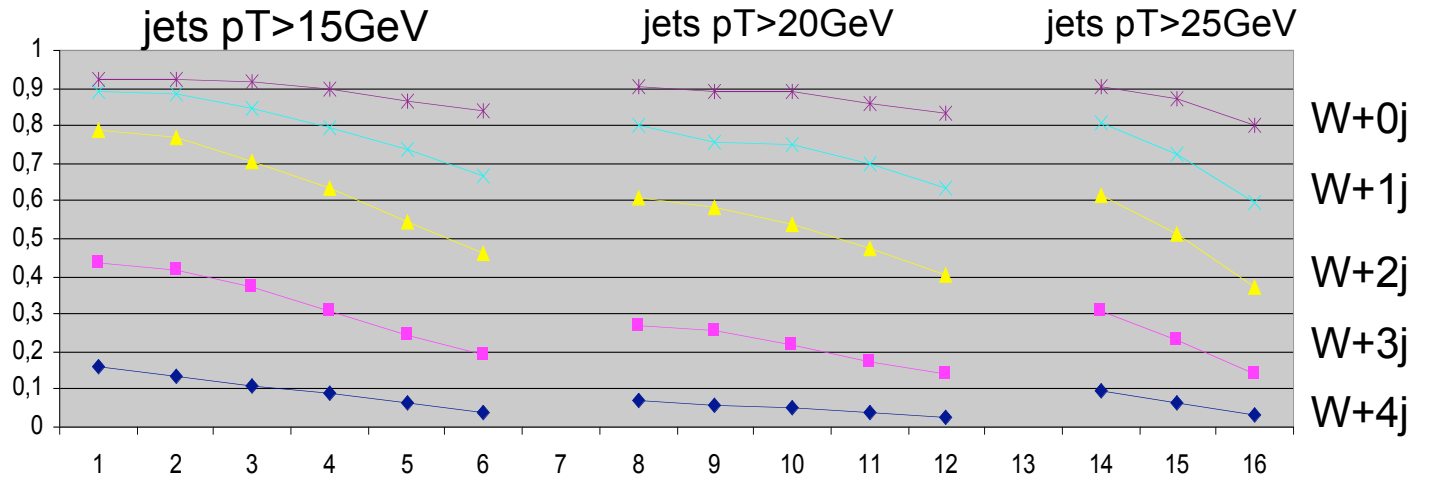
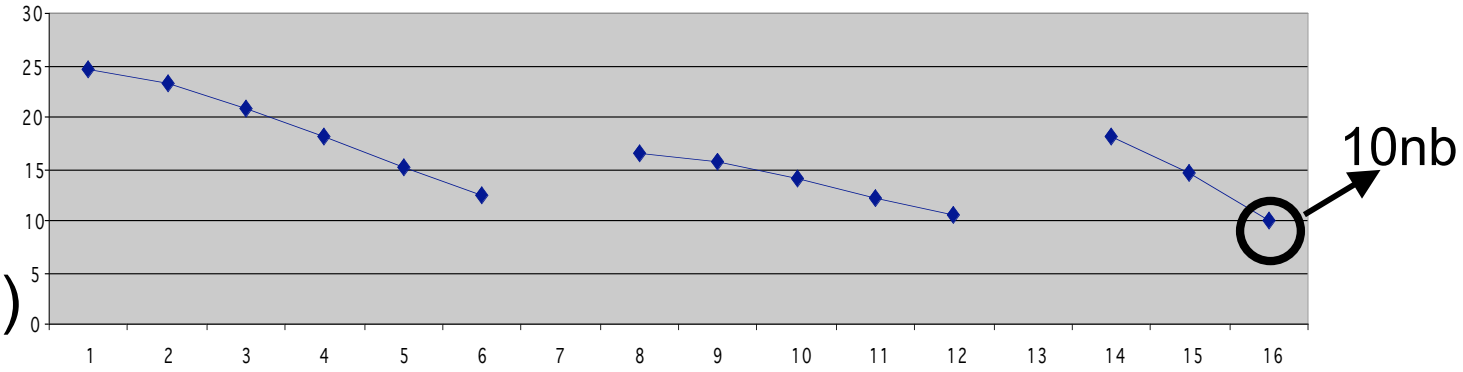
Efficiency



Effective Xsection (nb)



t-channel specific filter

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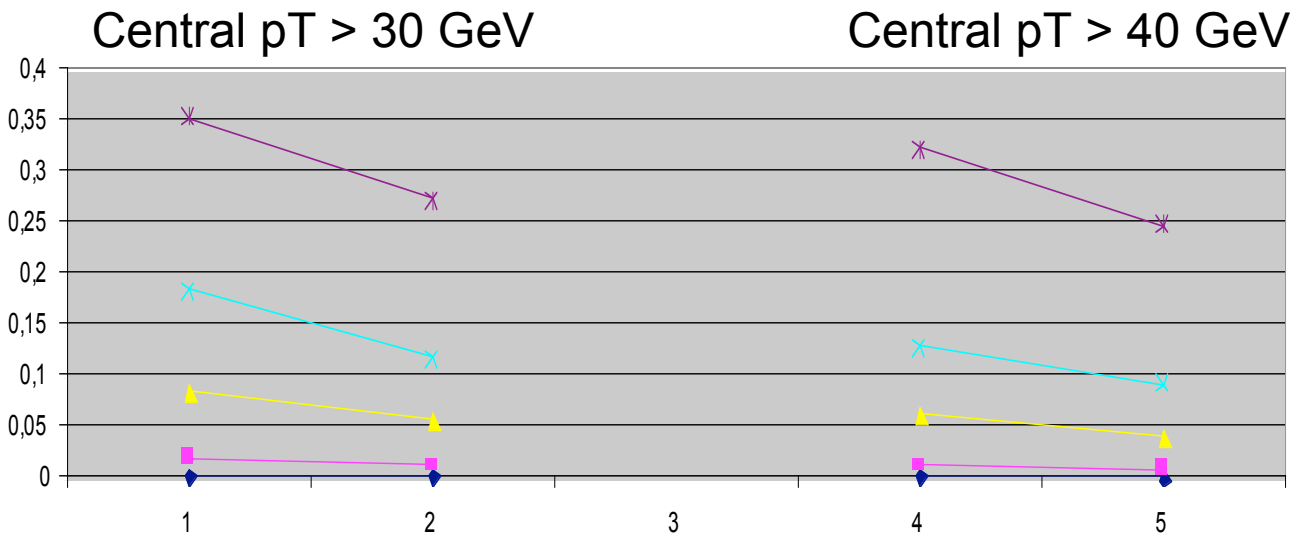
At least 2 jets, lepton P_T>20 GeV, MET>15 GeV

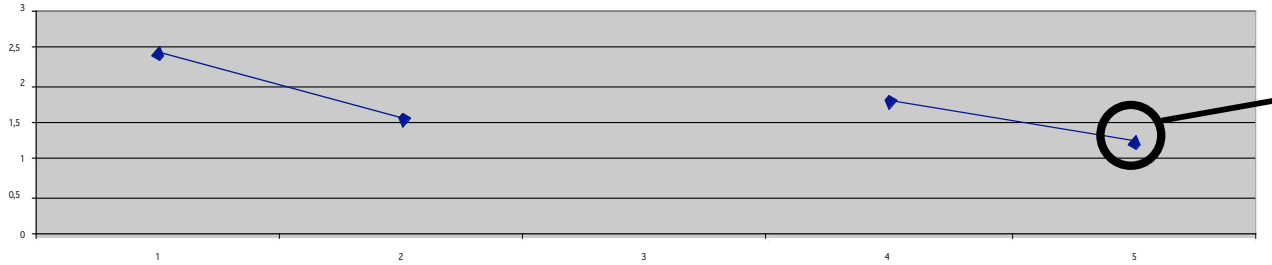
1 central jet (b from top) P_T> 30 – 40 GeV, |η|<2.5

1 forward jet (light) P_T> 30 – 40 GeV, |η|>2.5

Efficiency



Effective Xsection (nb)



Common ntuple infrastructure

- TopView is used by the majority of the group
  - https://twiki.cern.ch/twiki/bin/view/Atlas/TopView
- Preselection of objects following the analysis strategy:
  - https://twiki.cern.ch/twiki/bin/view/Atlas/TopViewPreselection
  - Muon selection
  - Electron selection
  - Jet /btagging
  - Tau

ParticleJet Selection

- "etCut":15*GeV,
- "deltaRCut":.3,
- "makeEtaCuts": False,

Objects with

- "useWeight":True,
- "weightCut":3

Electron Selection

- "etCut":20*GeV,
- "onlyEgamma":True,
- "useIsEM":True,
- "useTRT":False,
- "useNN":False,
- "useIsolation":True,
- "isolationCone":0.20, # in deltaR
- "absoluteIsolationCut":6*GeV,
- "makeEtaCuts": False,

Muon Selection

- "etCut" : 20*GeV,
- "onlyHighPt" : True,
- "isolationCone" : 0.20,
- "absoluteIsolationCut" : 6*GeV,
- "relativeIsolationCut" : 0,
- "useChi2FromCombinedMuon": False,
- "chi2NdofCut":20,
- "makeEtaCuts": False,

MC Validation

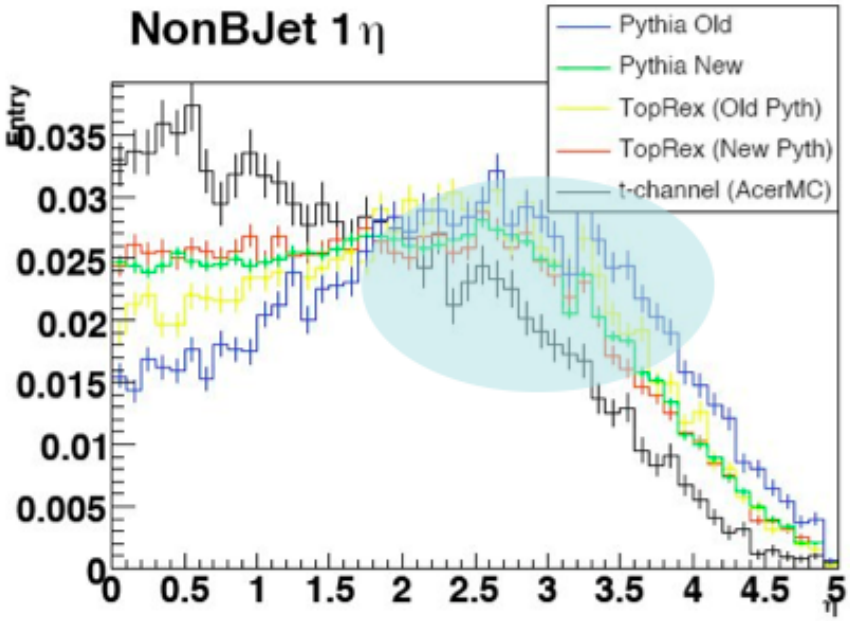
Summary

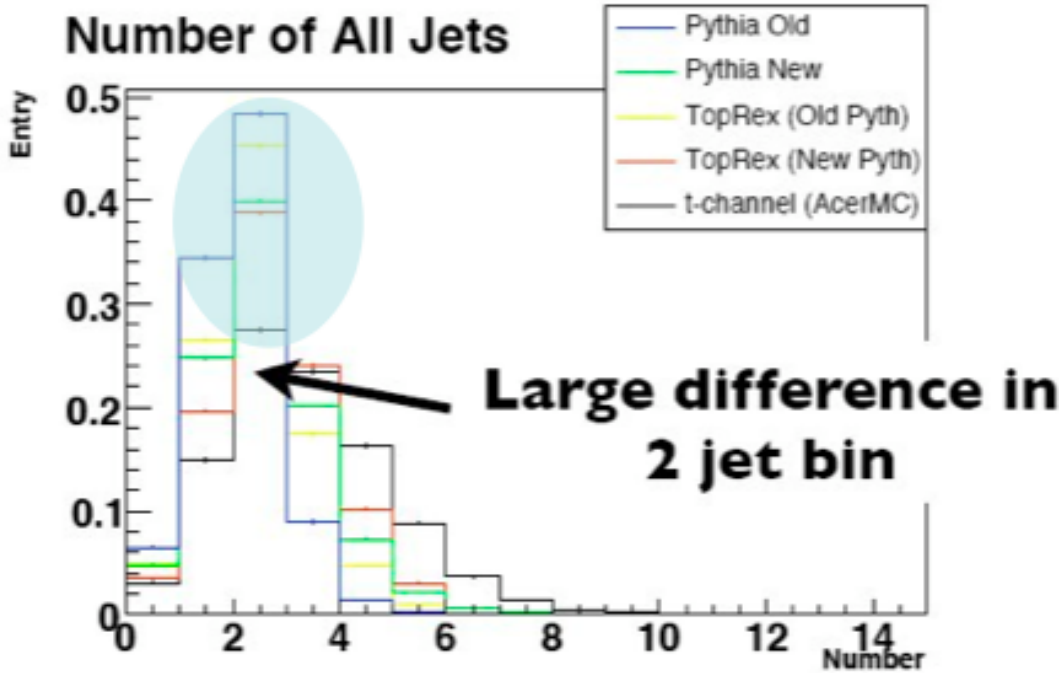
- S-channel shows reasonnable agreement
  - TopRex vs AcerMC
- Wt-channel shows some small differences
- T-channel MonteCarlo
  - Significant effects in jet distributions AcerMC vs TopRex
    - → Can not be explained by New Pythia Showering, choice of pdf's
    - → AcerMC distributions seem in better agreement with NLO computations
  - Effects are important for the t-channel analysis:
    - → Directly affects the selection strategy (no more "fwd jet" in 3-jet final state)
- Plans:
  - Quantify the agreement MCFM vs AcerMC
    - → disentangle parton effects from jet reco effects etc…
  - Need to compare with MC@NLO generator
    - → Need to solve the pbme of HERWIG interface with MC@NLO

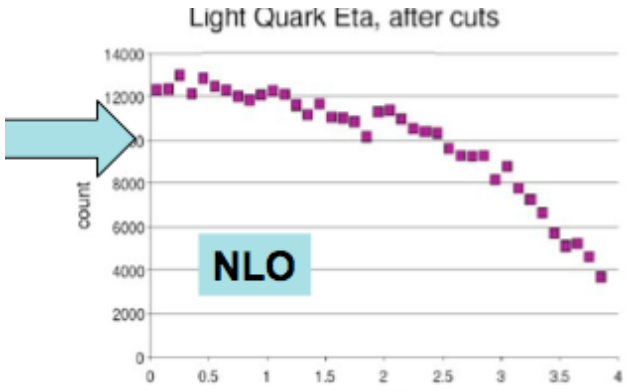
MC Validation: t-channel

Differences in TopReX vs AcerMC

- In jet multiplicity
- In light jet eta/pT distributions







MC Validation: t-channel

Tried to disentangle the effects

New Pythia Showering:

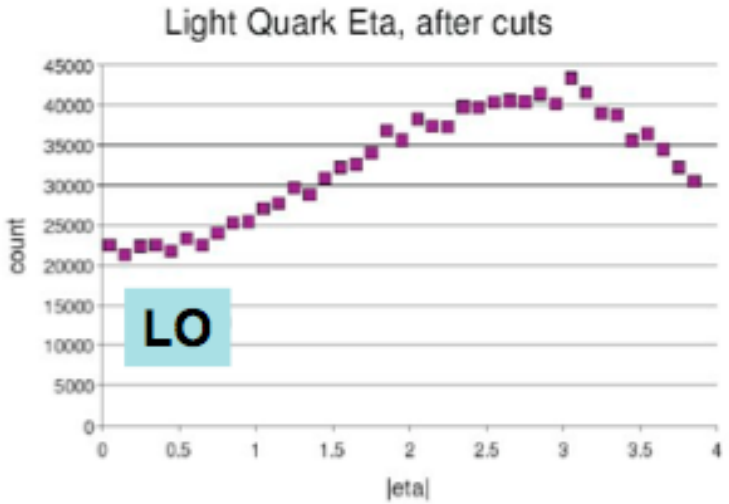
- Use of TopRex w/ new PS
- → Although not validated w/ new PS could *not* explain the effect

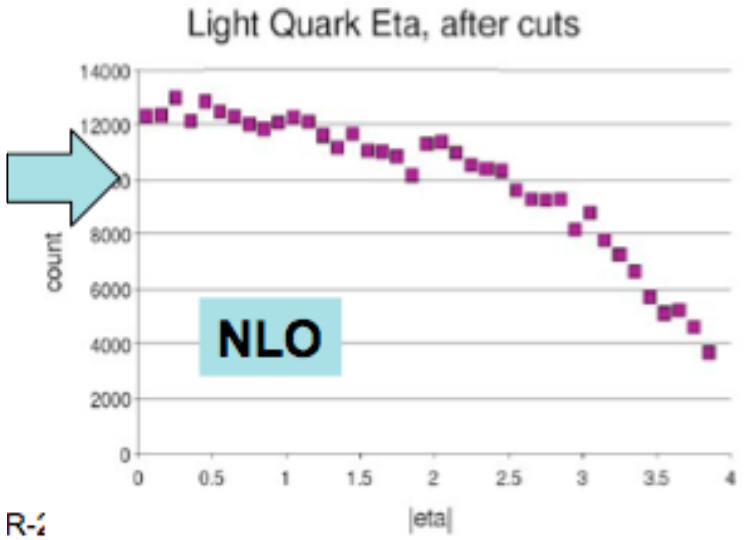
Use of different PDF's

- Sizeable difference between CTEQ5L, CTEQ6L etc…
- → Can *not* explain the difference

Cross-checks with NLO computations

- MCFM
- Only partonic level
- → NLO affects significantely the jet distribution !
- → NLO seems to be well reproduced by AcerMC



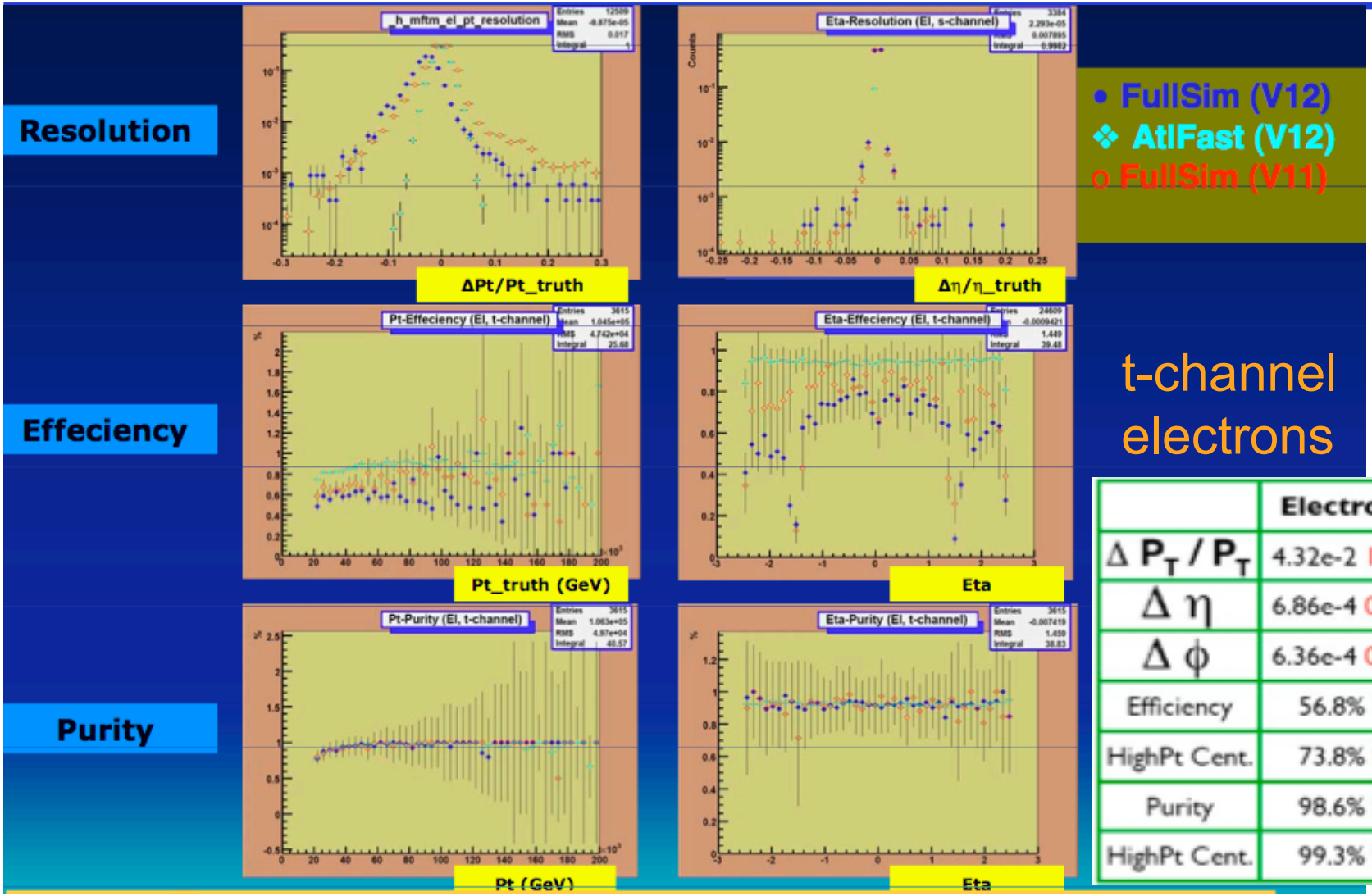


Reconstruction Performance

Estimators:

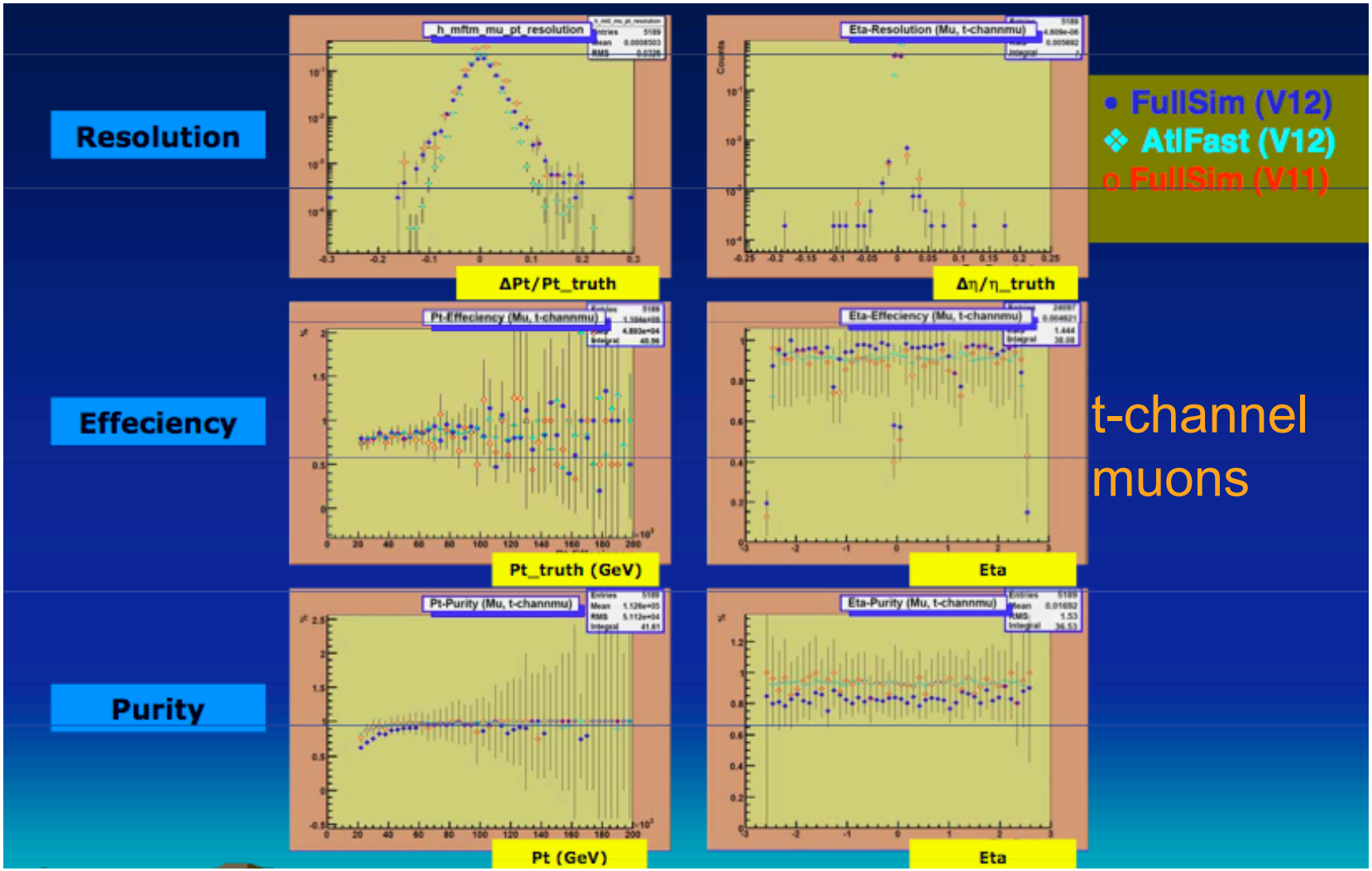
- **Efficiency** = Number of Reconstructed Objects that match to a Truth Object/ Number of Truth Objects (bin by bin - Eta bins)
- **Purity** = Number of Reconstructed Objects that match to a Truth Object / Number of Reconstructed Objects (bin by bin - Eta bins)
- **PT or η resolution** = PT or η of the reconstructed object/ PT or η of the truth matched objects
- **Jet matching** = DeltaR(jet1,jet2) < DeltaRCutOff (0.2,0.1,0.05)

Reconstruction Performance

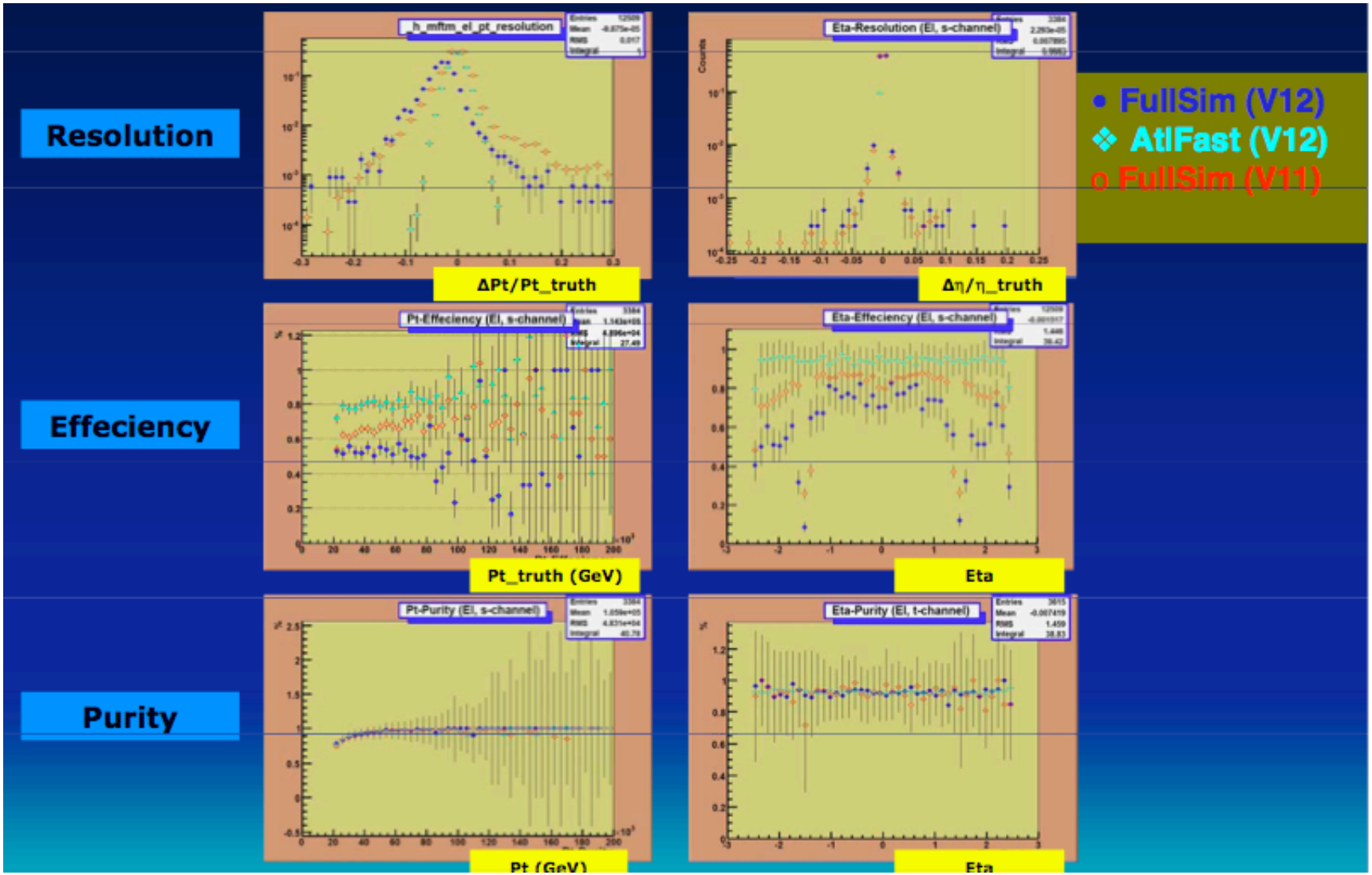


	Electron (dR:0.05)
$\Delta P_T / P_T$	4.32e-2 1.95e-2 4.28e-2
$\Delta \eta$	6.86e-4 0.00e-0 6.60e-4
$\Delta \phi$	6.36e-4 0.00e-0 6.26e-4
Efficiency	56.8% 79.3% 75.5%
HighPt Cent.	73.8% 91.0% 84.4%
Purity	98.6% 99.5% 99.6%
HighPt Cent.	99.3% 99.9% 99.8%

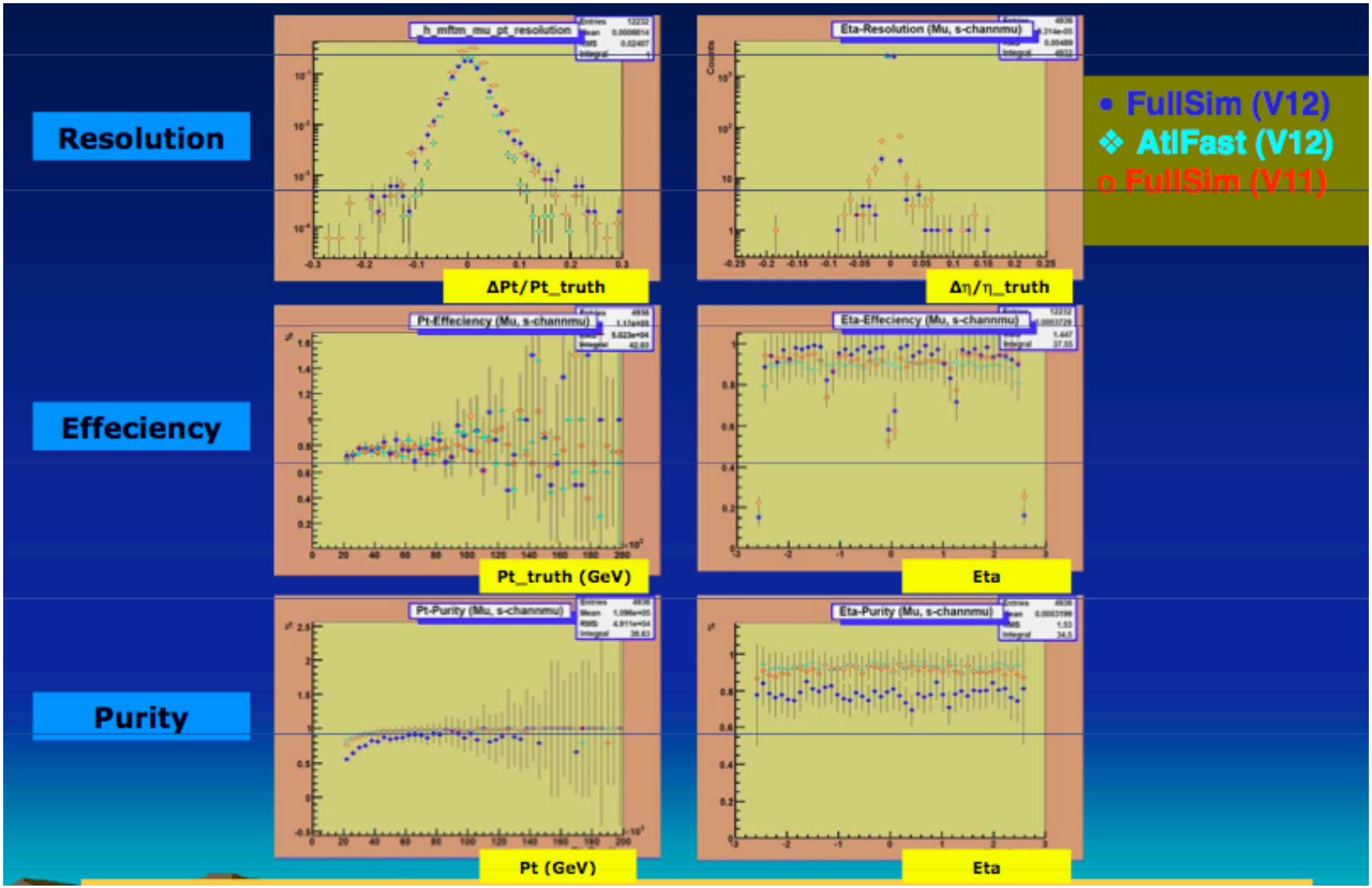
Reco Perf: Muons



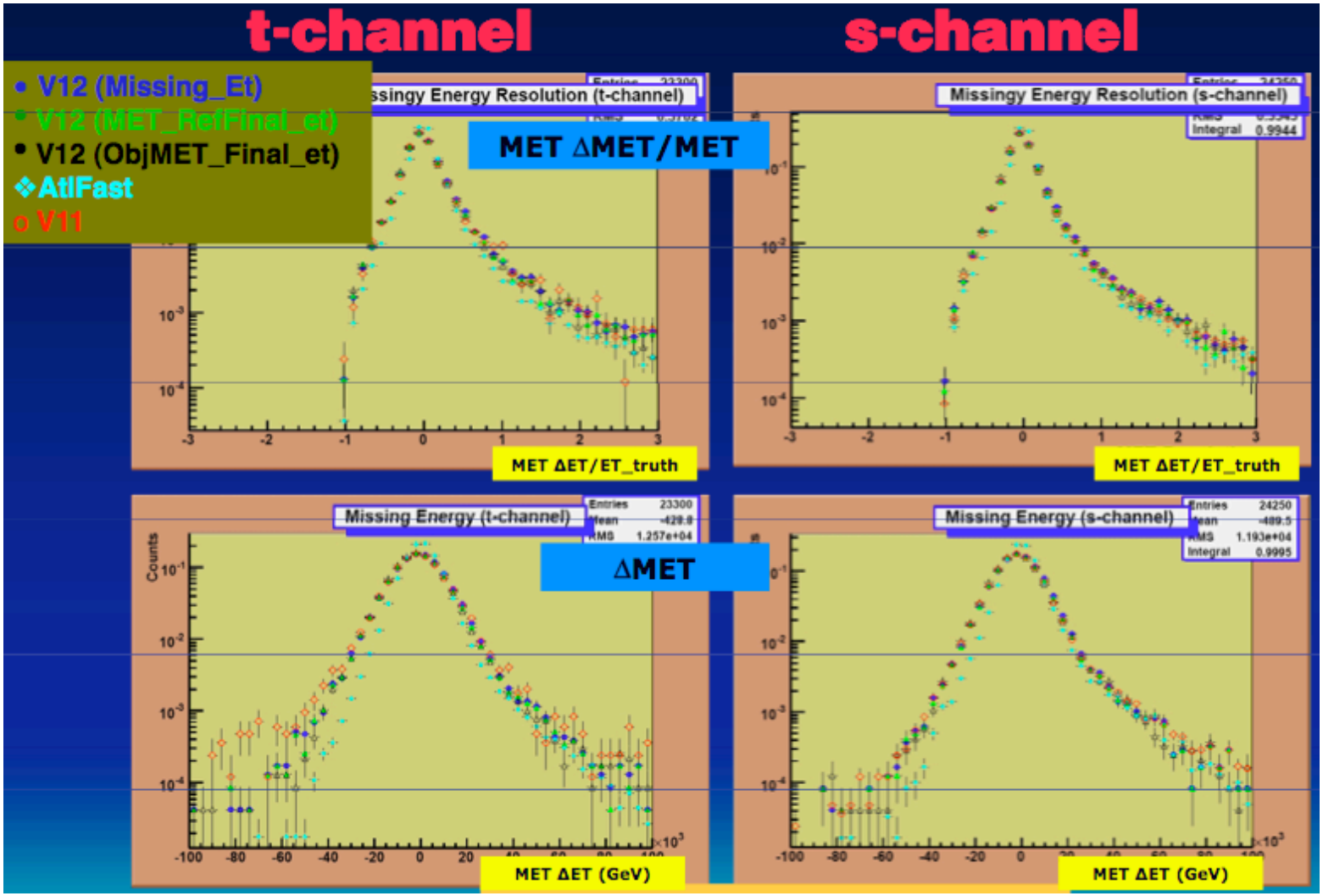
Reco Perf: s-channel electrons



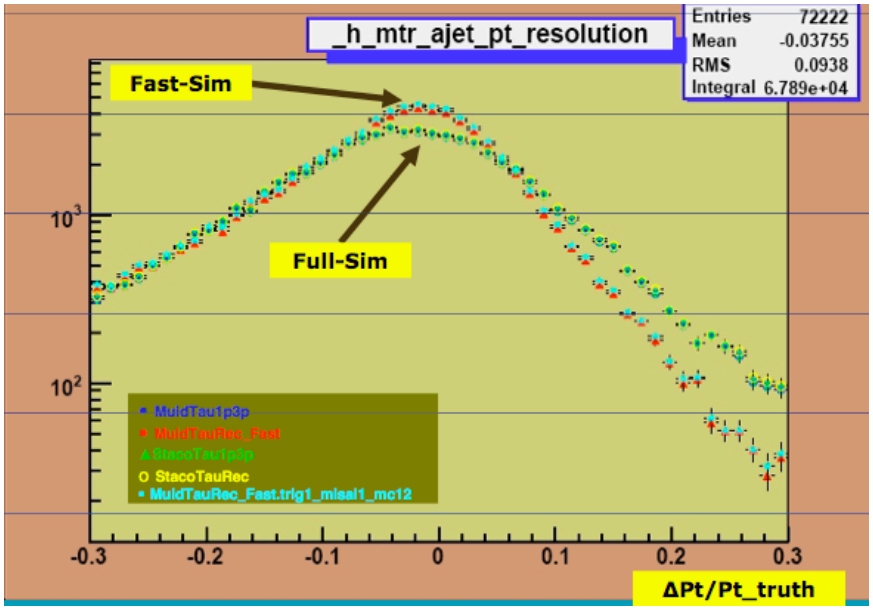
Reco Perf: s-channel muon

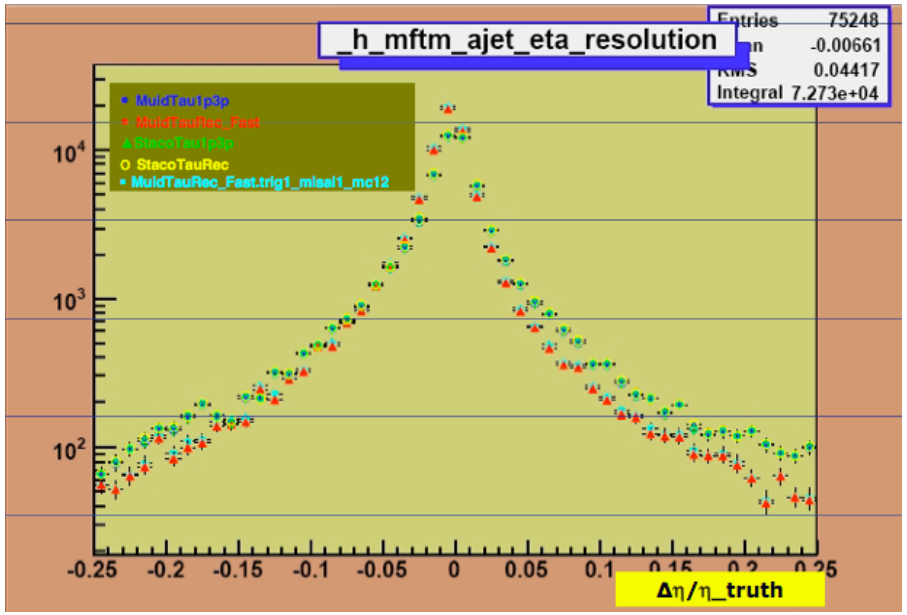


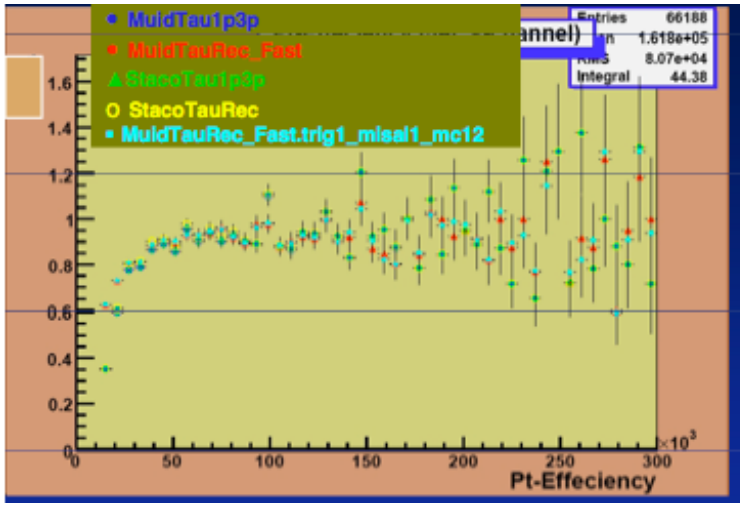
Reco Perf: MET

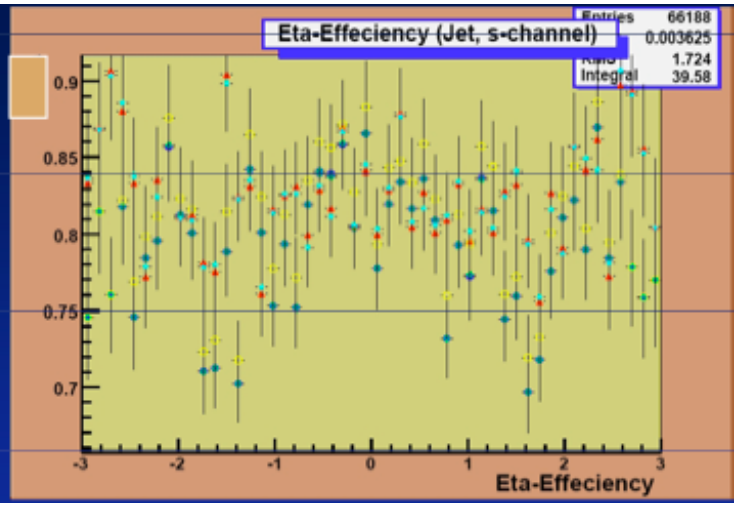


Reco Perf: Jets (s-channel)



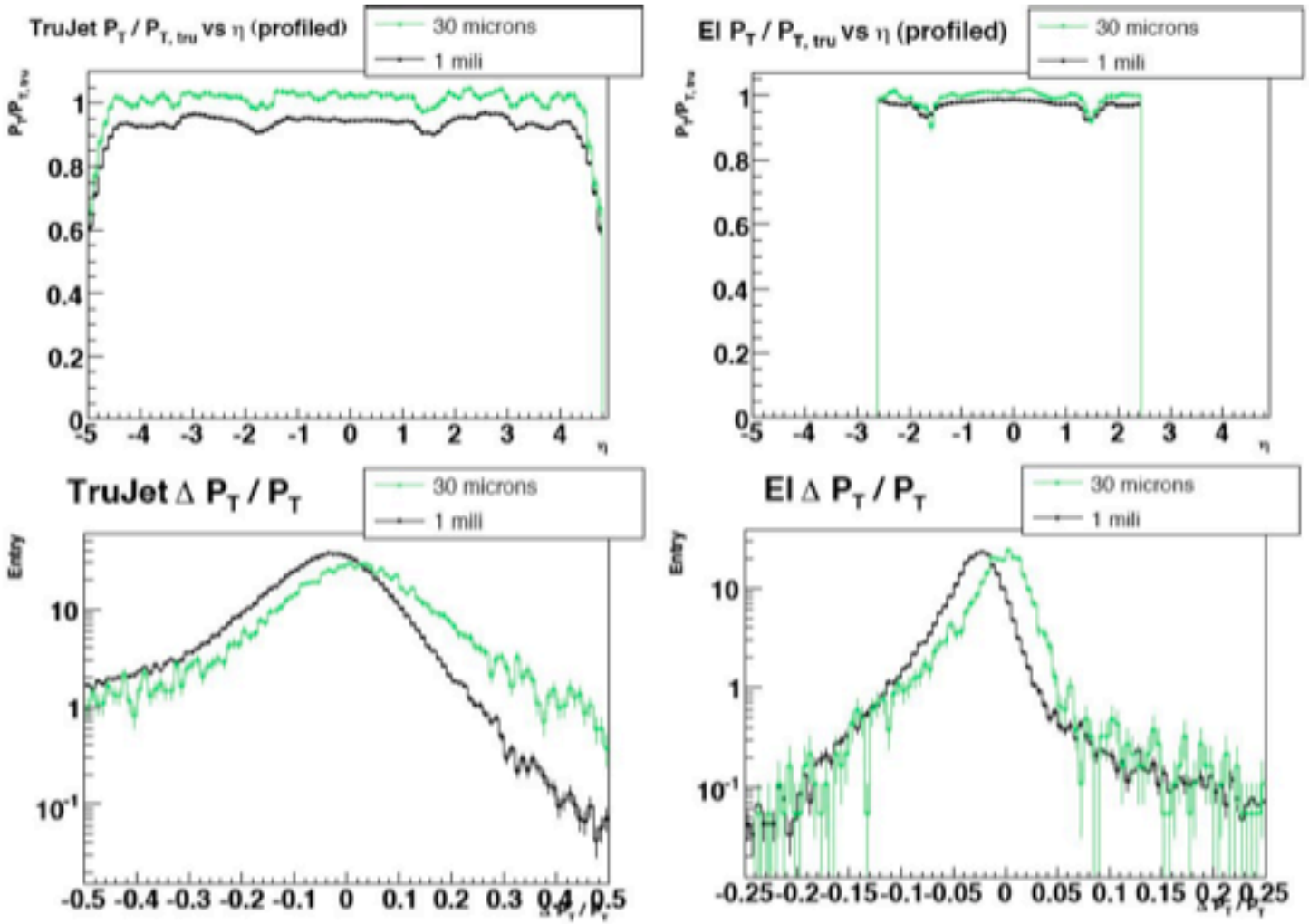






Effects of LAr range cut (1mm vs 30μm)

Main effects are seen on resolution



Effects of LAr range cut (1mm vs 30μm)

Effects of LAr Range cut

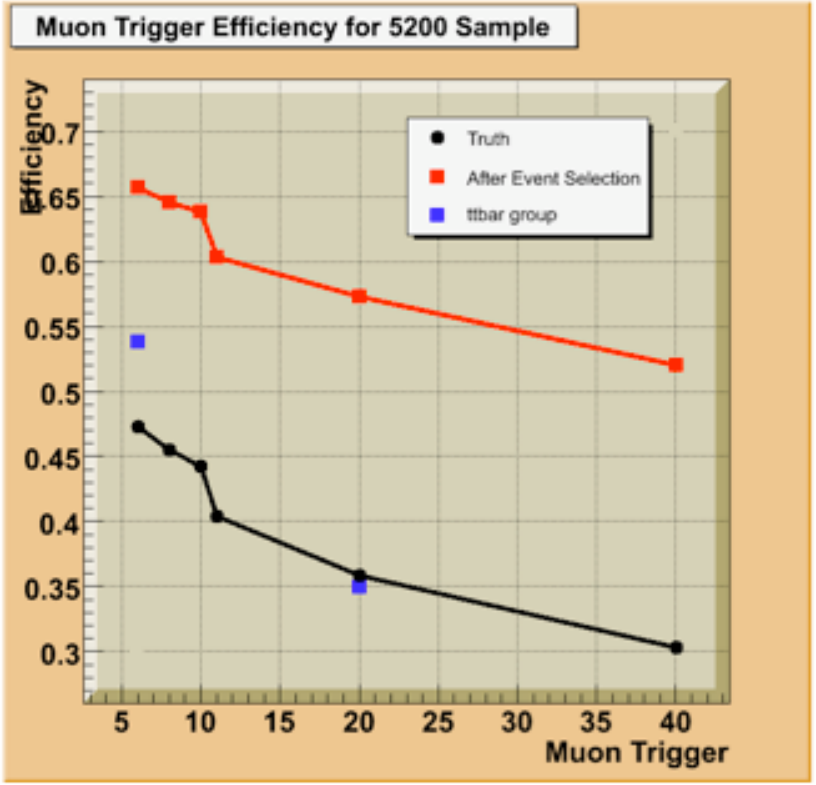
- Main effects seen on resolution
- Small effects on single-top efficiencies
- But, all analyses are dominated by systematics:
  - T-channel : presence of a fwd jet sensitive to the bug in FCAL
  - Wg, Wt, W*: effects on JES (we use reco W and top mass) ?

- Plans:
  - Reproduce the analyses using 30-micron samples as they become available
  - Assess the systematic effects using 30-micron signal samples
  - We have required:
    - 50k Wg 30-micron sample
    - 25k W* and W+t 30-micron samples

Trigger Studies

Triggers on single-top

- Studies just started
  - L1 Inclusive Muon Trigger tested :
  - → MU11, *MU20*, *MU40*
  - → Calibrate results on ttbar sample first
  - L2 muon to follow
- To follow :
  - Inclusive electron trigger
  - Jets triggers next
  - Specific trigger for single-top :
    - → Lepton + jet trigger (a la Dzero) ?
- TopView trigger Tree
  - Trigger tree no more in v12
  - Would like to have it back…
    - → not just if event passes / fails



Red line: Reconstructed efficiency

- Trigger applied after common single top selection
- Similar trend to truth sample
- About 20% higher than truth efficiency

B-tagging performance

Performance Estimators

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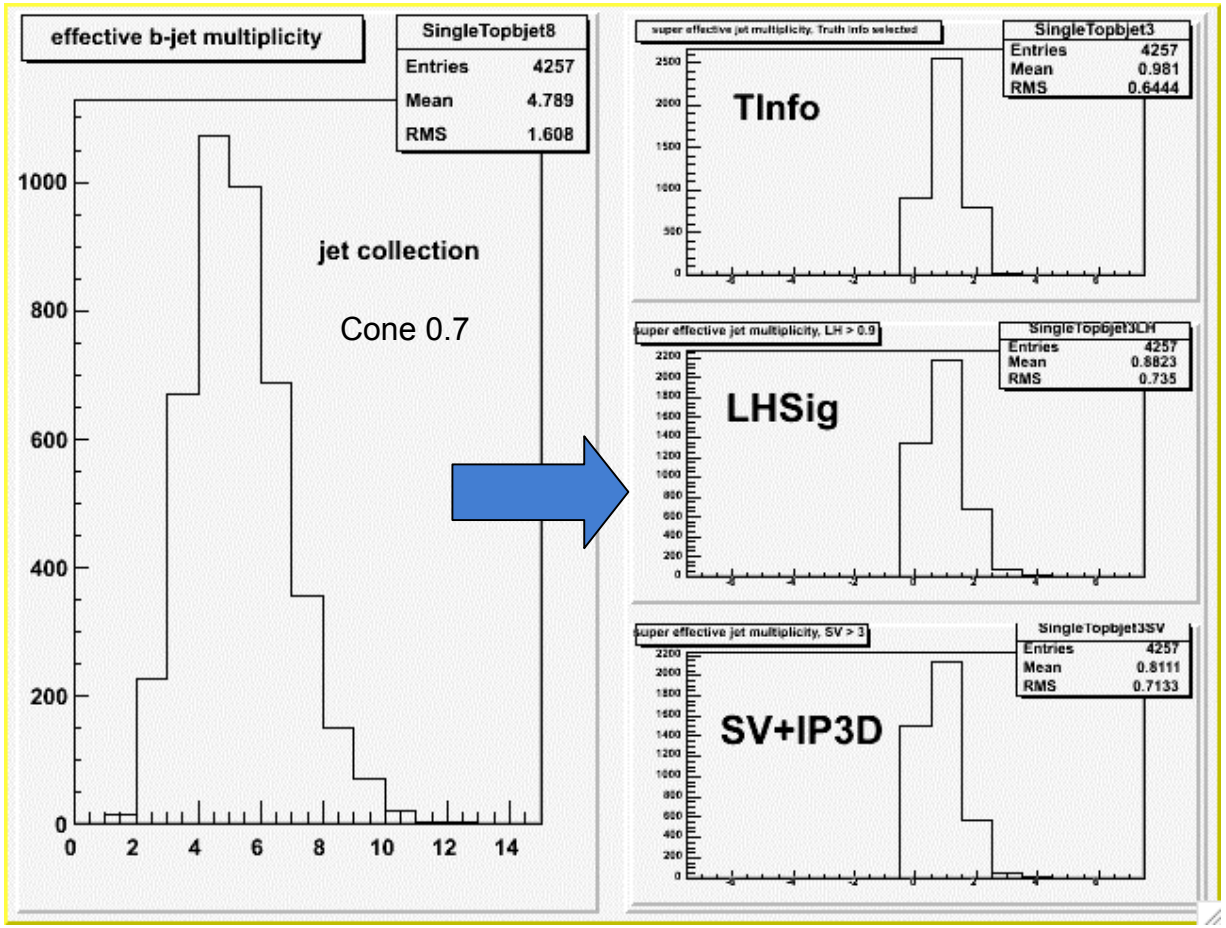
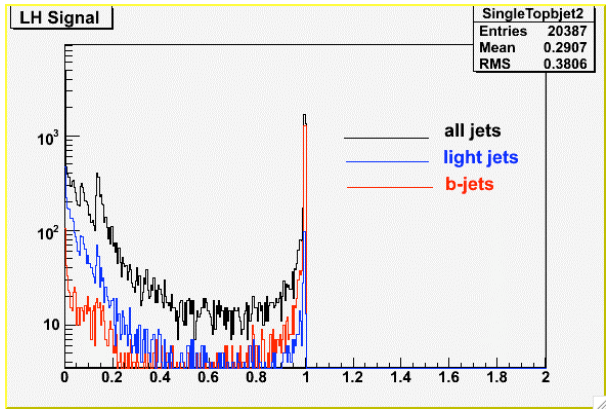
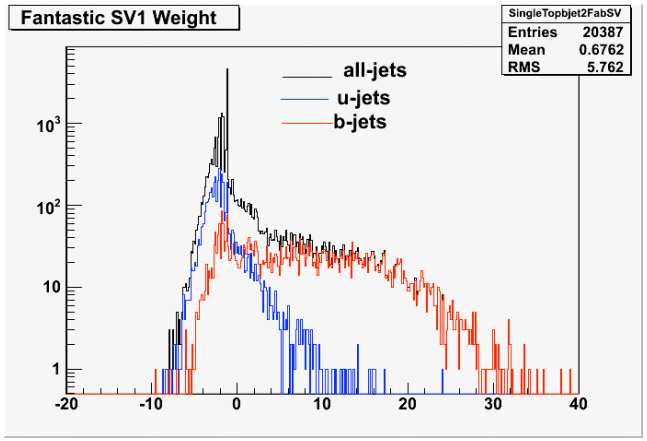
- B-jet efficiency ε_b as function of variable cut:
  - Denominator:
    - jets defined as b using MC truth
      - with fixed p_T and η cuts (p_T> 50 GeV/c, $|\eta|$<2.5)
  - Numerator:
    - ditto + cut on a tagging weight
- Light-jet rejection $R_u = 1 / \varepsilon_u$
  - R=100 means 1% mistag rate
  - light jets: u, d, s, g
- B-jet efficiency as a function of P_T and η
  - Denominator:
    - jets defined as b using MC truth
      - with fixed cut on weight (SV1 > 3, LHSig > 0.9)
  - Numerator:
    - ditto + cut on p_T and η

B-jet selection

From the Btag collection jets were selected using TruthInfo, LHSig (>0.9) and SV1 (> 3)

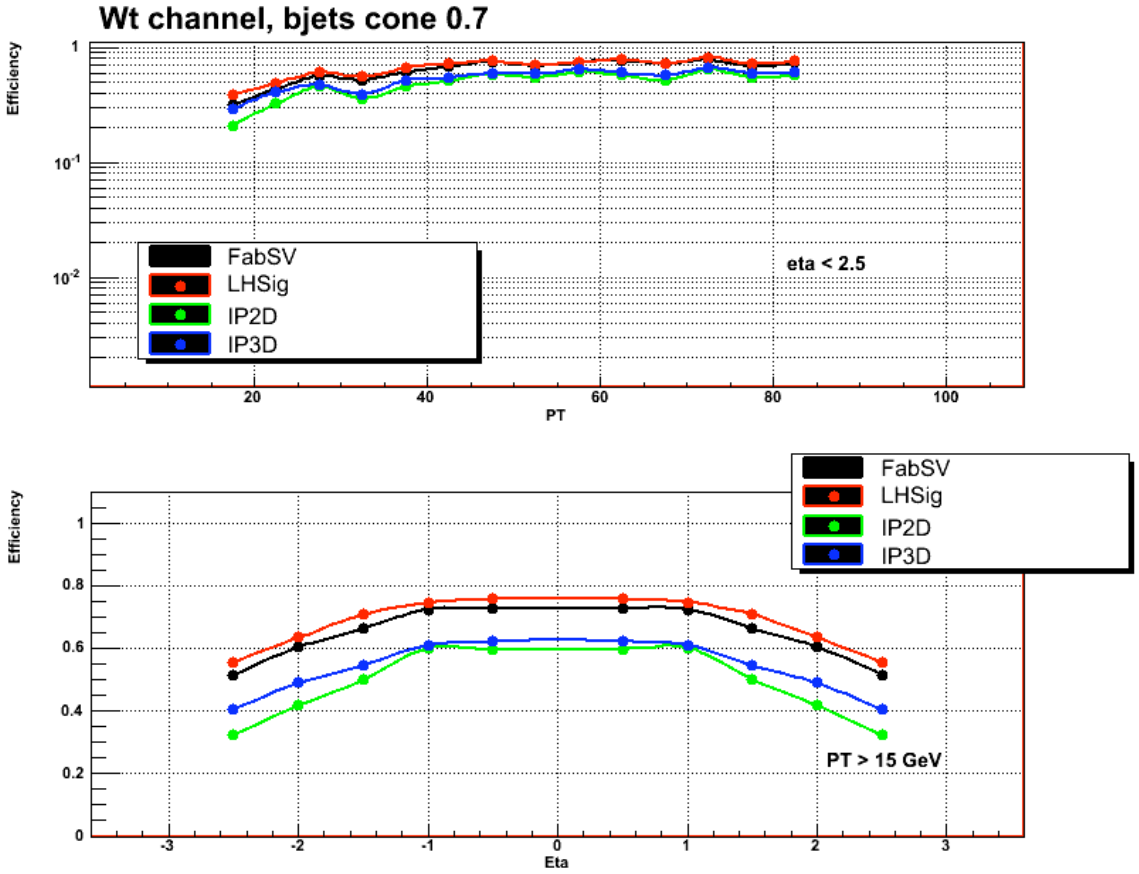






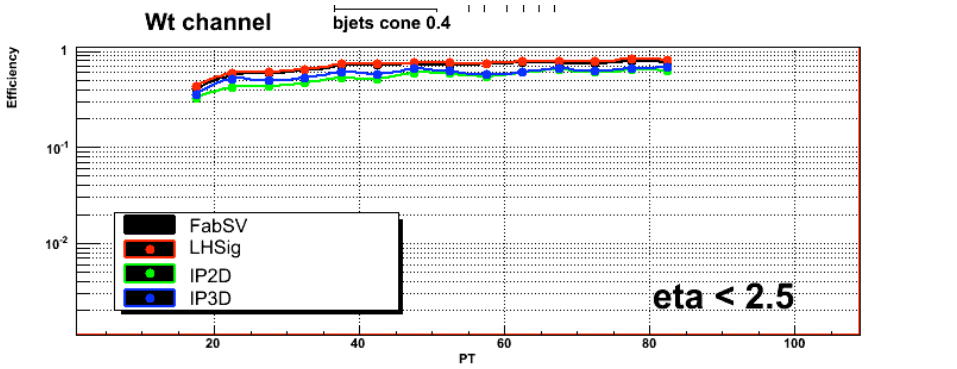
Btag Efficiency

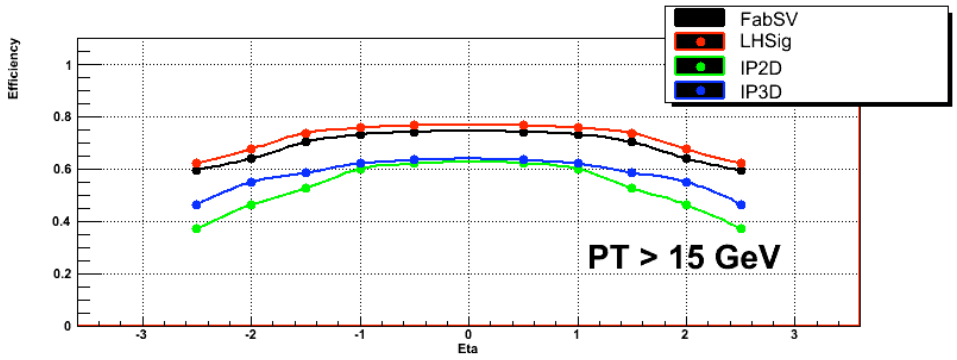
$$\varepsilon = \frac{\text{Number of tagged jets in Pt/}\eta\text{ range passing cut}}{\text{Number of tagged jets in Pt/}\eta\text{ range}}$$



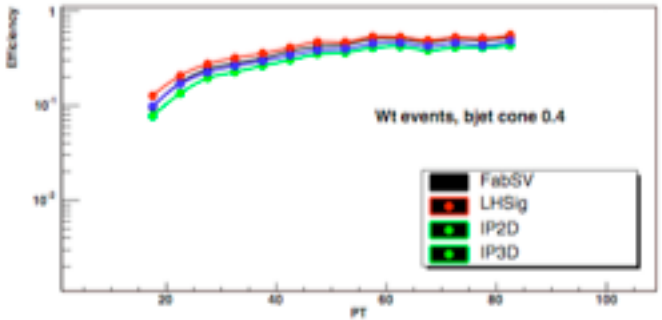
Wt efficiencies

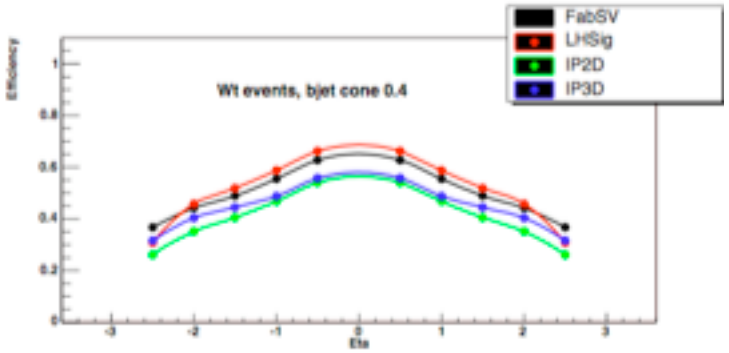
12.0.6





10.0.1 + patches

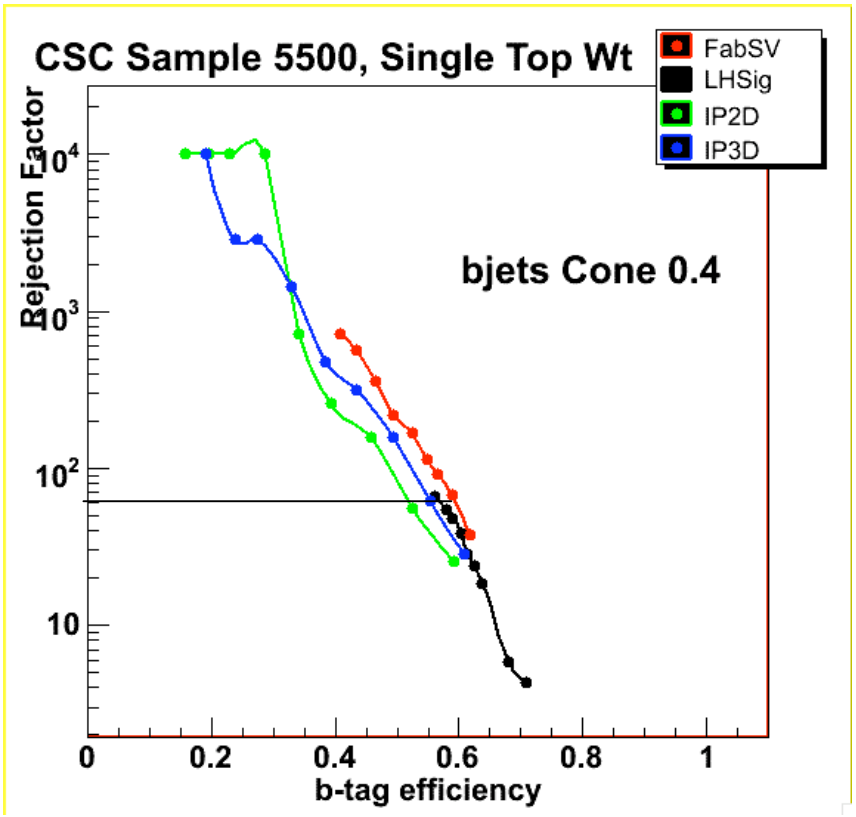




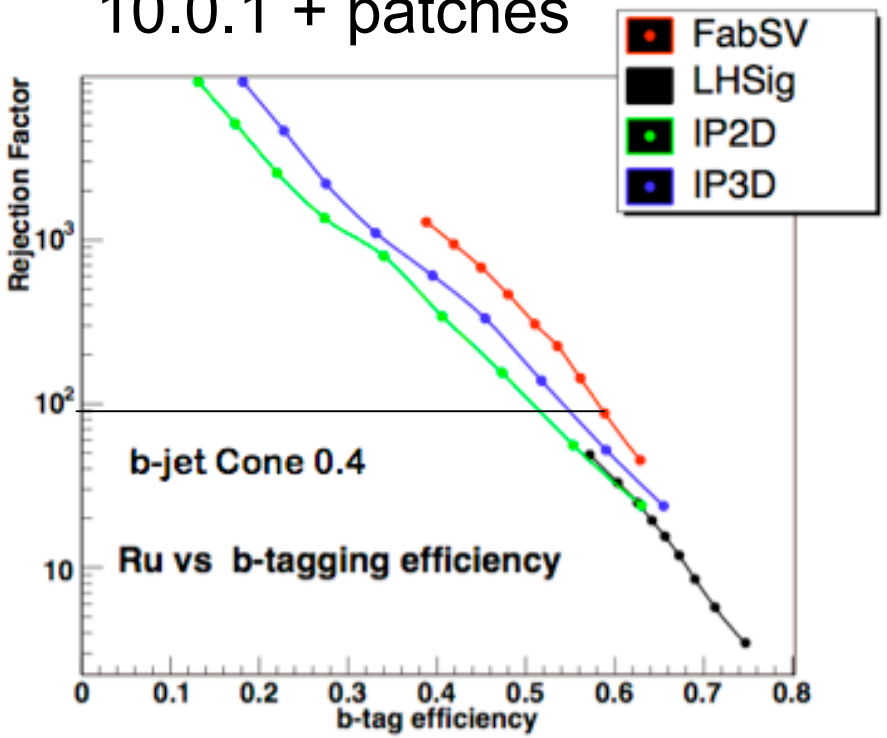
Rejection Factors

CSC sample 5500, 5000 events

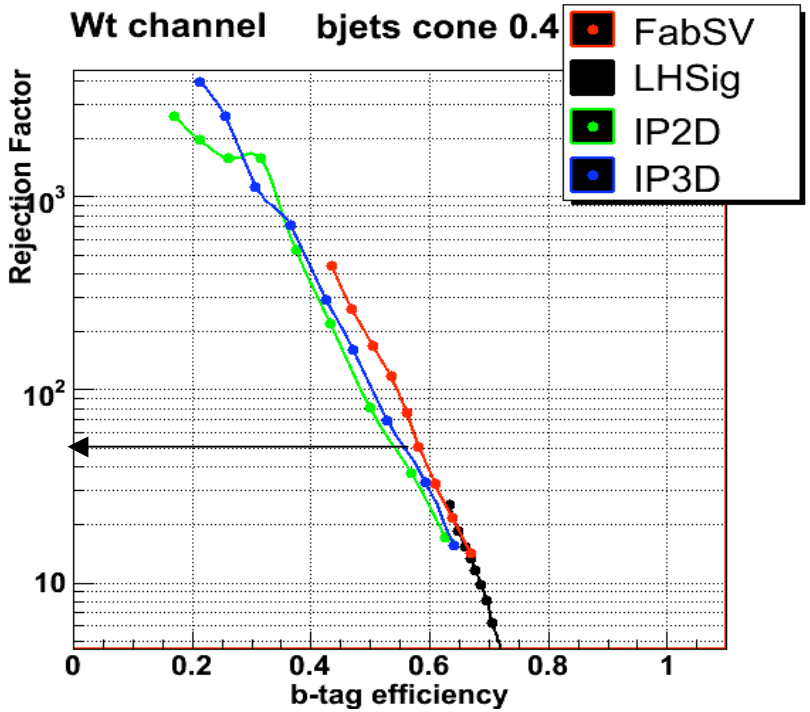
11.0.5

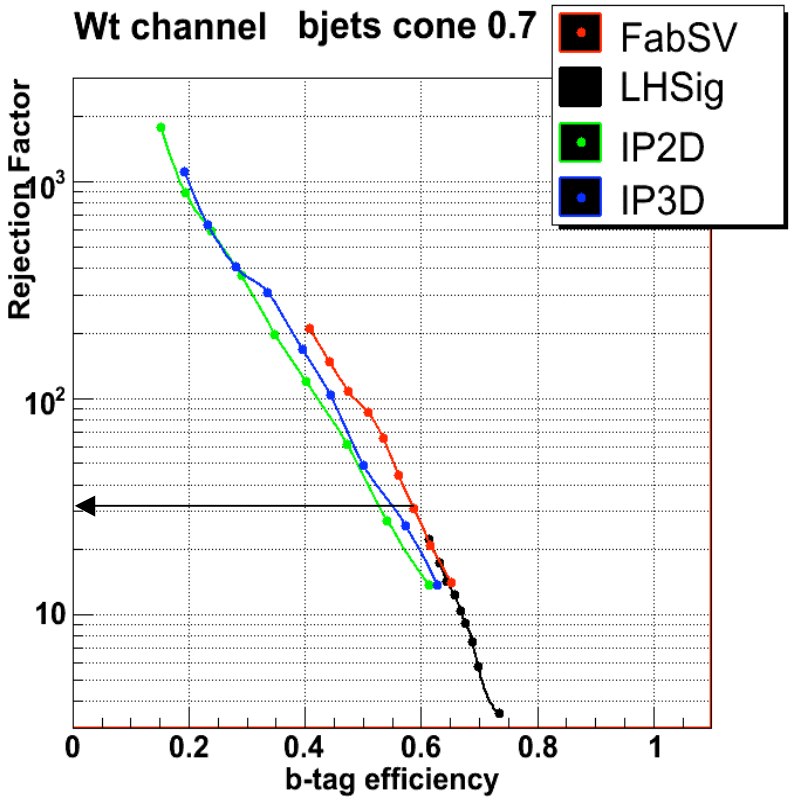


10.0.1 + patches



CSC 5500 v12

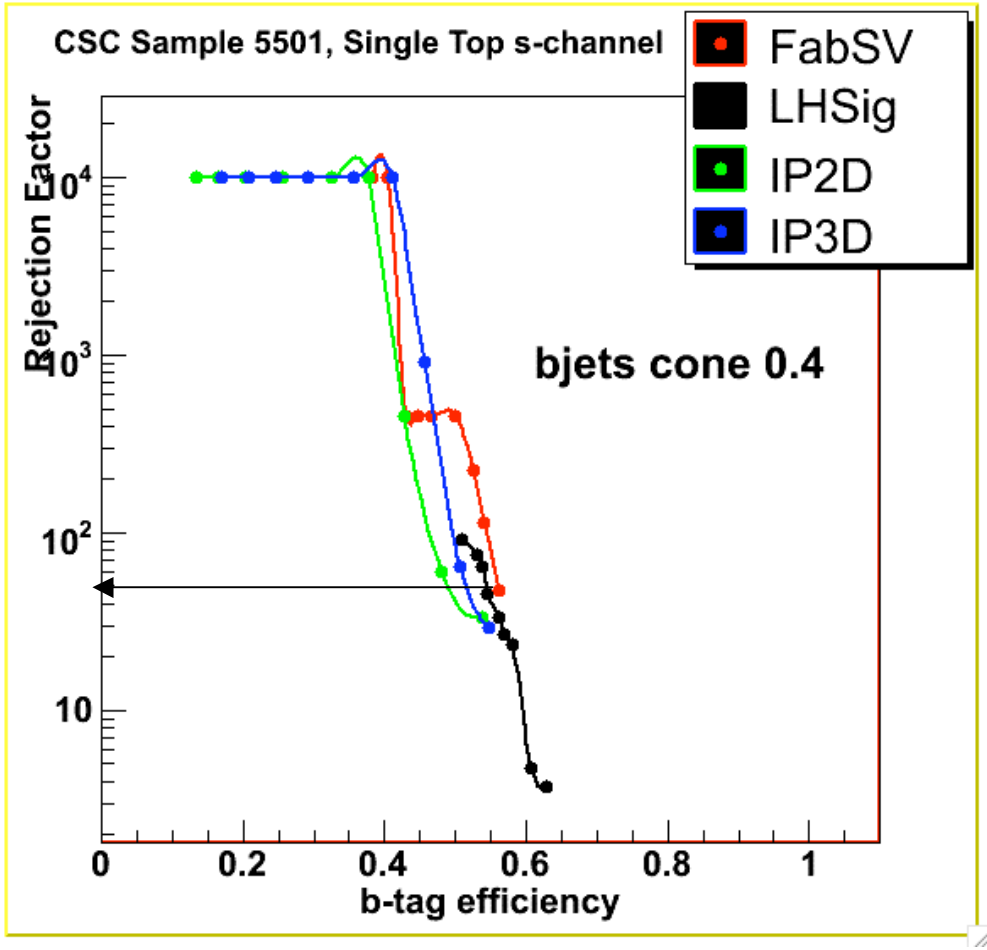

Wt channel bjets cone 0.4
FabSV
LHSig
IP2D
IP3D
Rejection Factor
10^3
10^2
10
0
0.2
0.4
0.6
0.8
1
b-tag efficiency


Wt channel bjets cone 0.7
FabSV
LHSig
IP2D
IP3D
Rejection Factor
10^3
10^2
10
0
0.2
0.4
0.6
0.8
1
b-tag efficiency

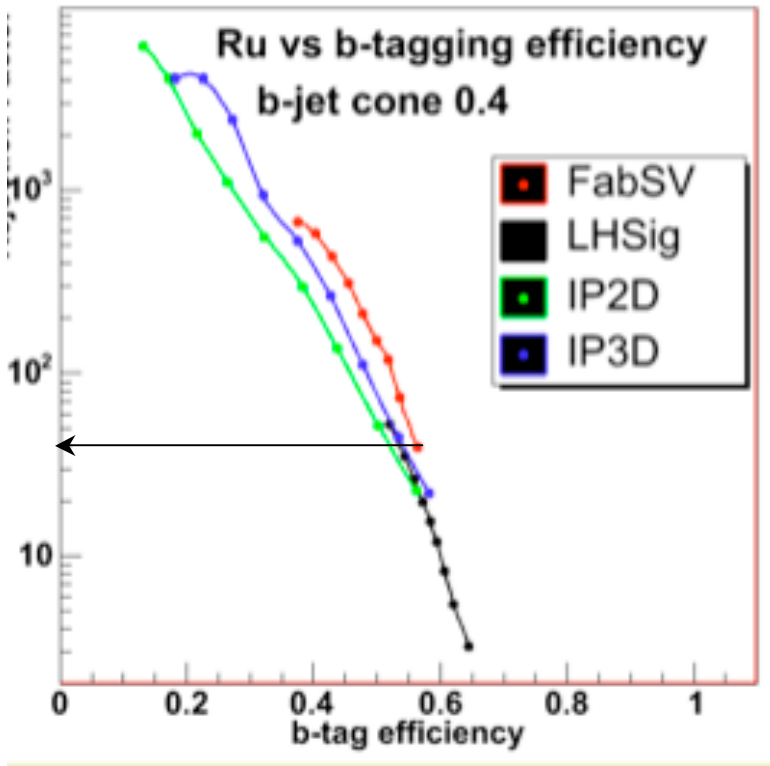
S-channel

CSC Sample 5501, 50k events

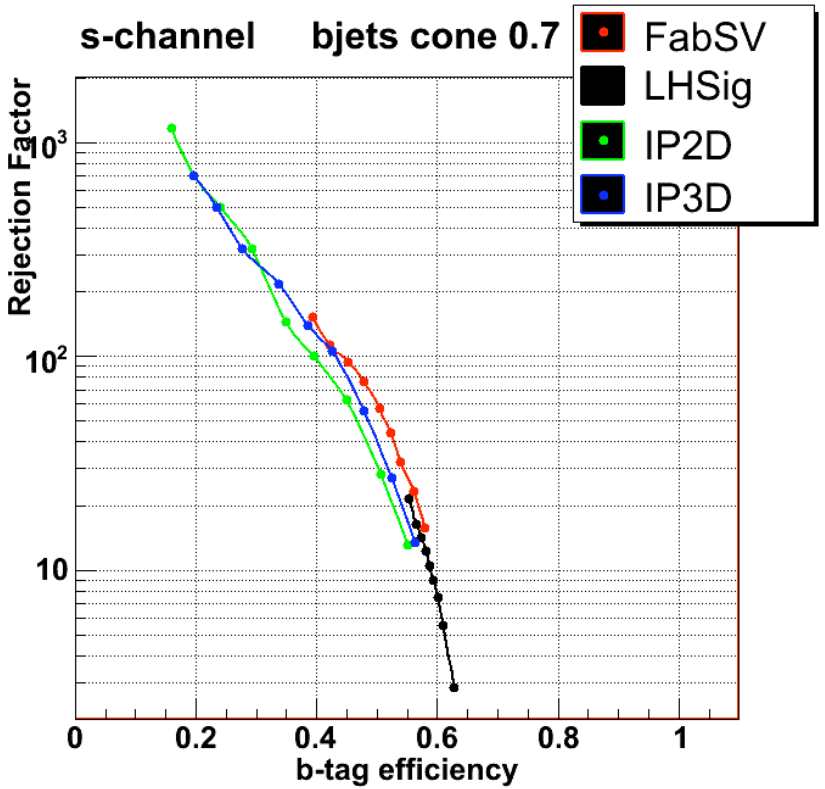
11.0.5

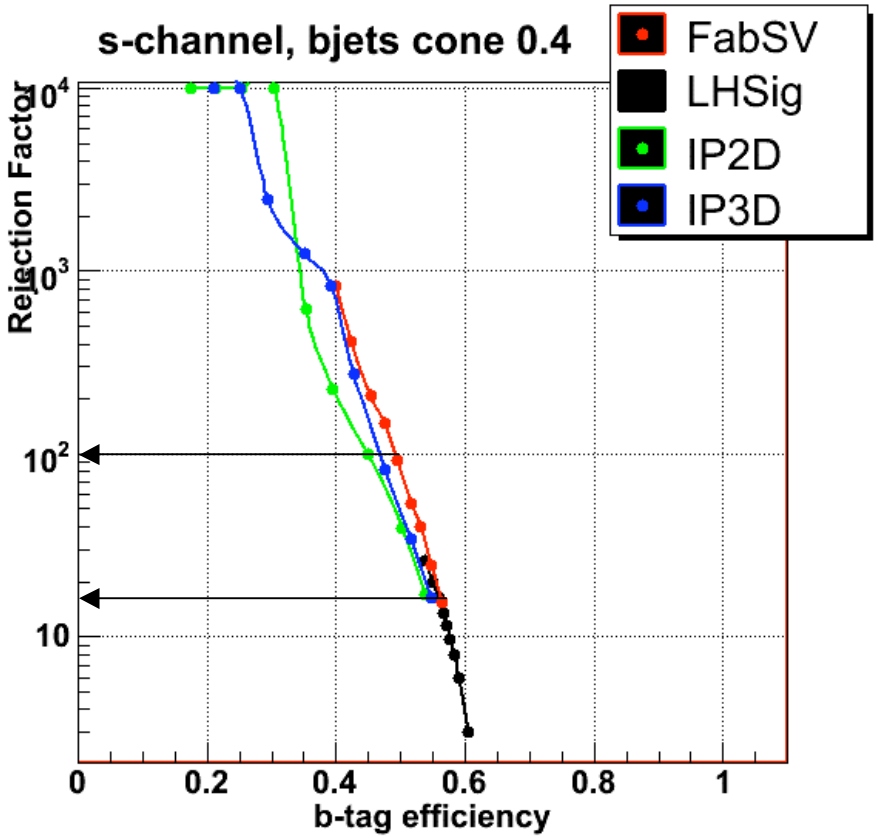


10.0.1 + patches



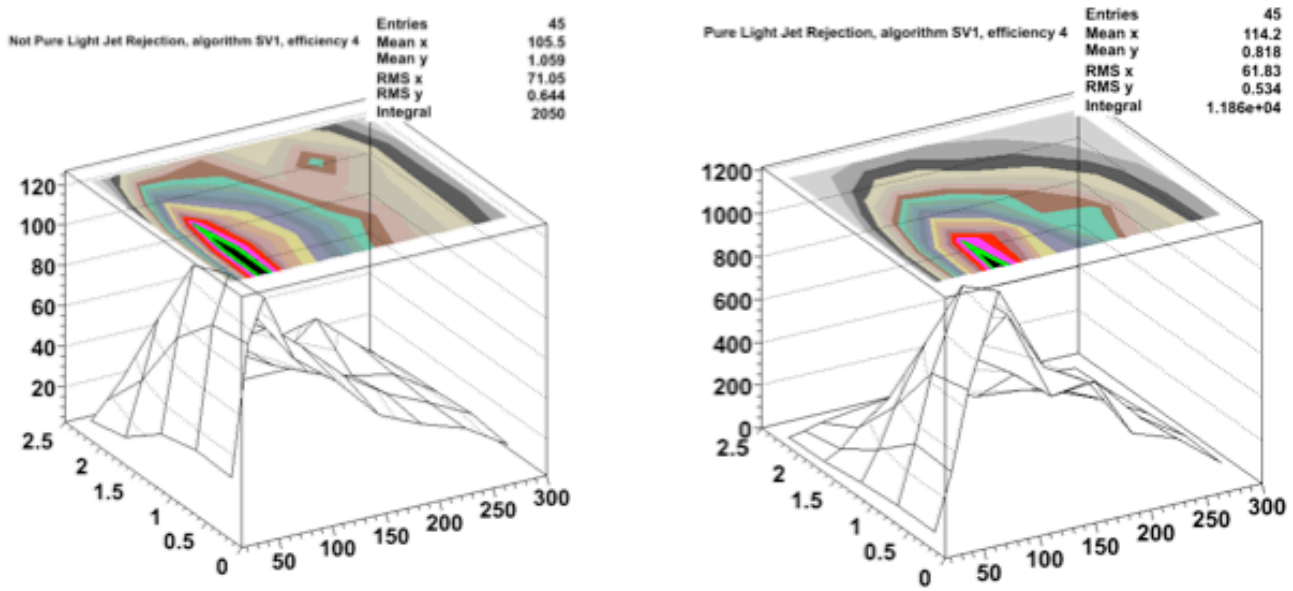
S-channel v12.0.6





TRF Tagging

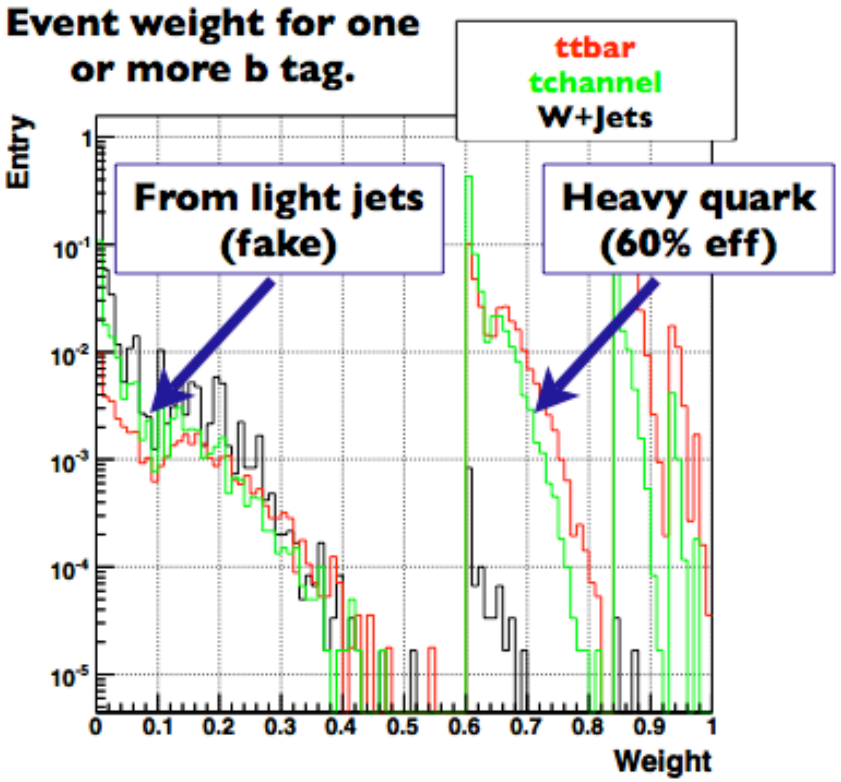
The Tagging Rejection Function (TRF) is a way to calculate an a priori event weight based on the efficiency to tag a b-jet (usually 60%).
It is applied to large statistics samples in order to avoid having to generate many events which are unlikely to survive a b-tagging selection.



Light jet rejection at eff 60%. (eta against pt)
Using parameter file by Jean-Baptiste
'non-purified' (left) and 'purified' (right)

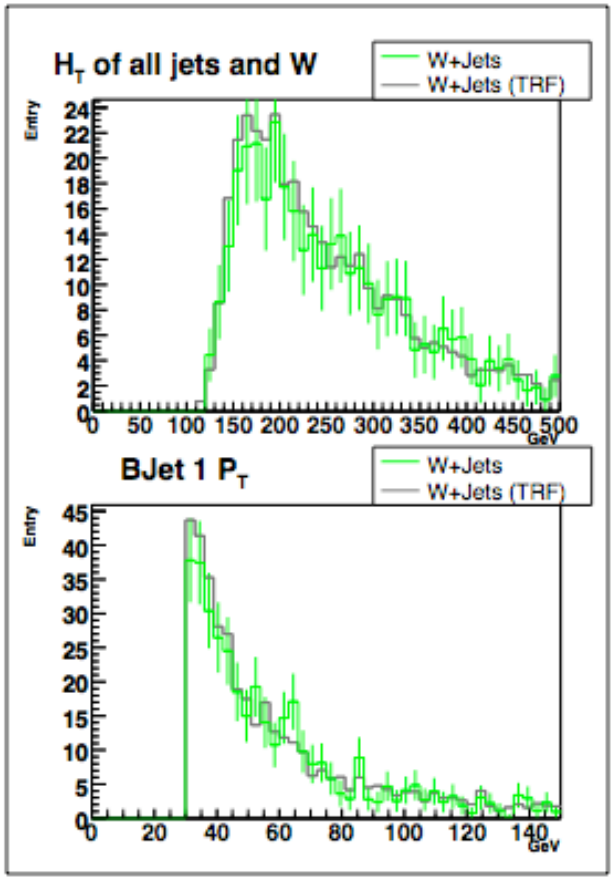
TRF Tagging (cont'd)

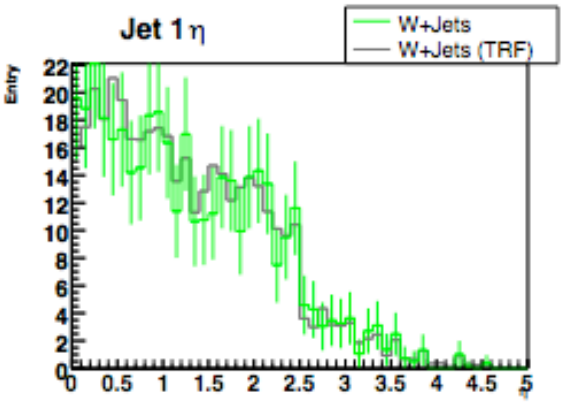
How does it work?
All the jets in the event are considered and the b-tag weight for a given algorithm is calculated (IP2D, SV1..). Based on this information an event-weight is produced and the event is retained/discarded based on the value of the weight.

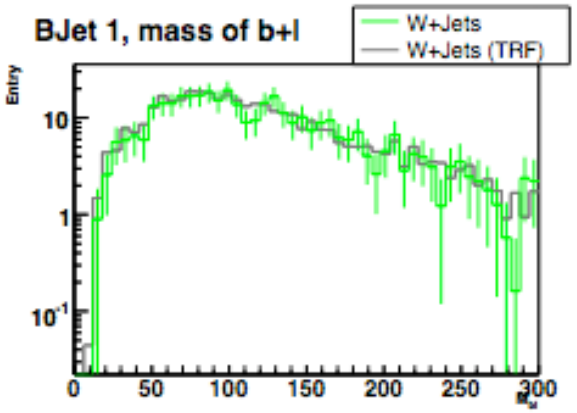


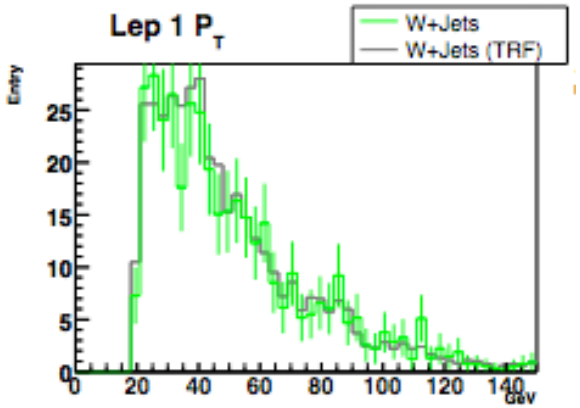
TRF tagging (cont'd)

Comparison between TRF samples and regular samples









Good agreement

Plots are scaled to the same luminosity

Individual Analyses

t-channel

- Progress made on t-channel selection
- Progress made on polarization measurements

s-channel

- Analysis to be completed by the next top WG meeting
  - Likelihood to be finalized
  - Triggers to be included
  - Systematics not started

Wt-channel

- Triggers to be implemented
- Tests different Multivariate techniques to improve discrimination

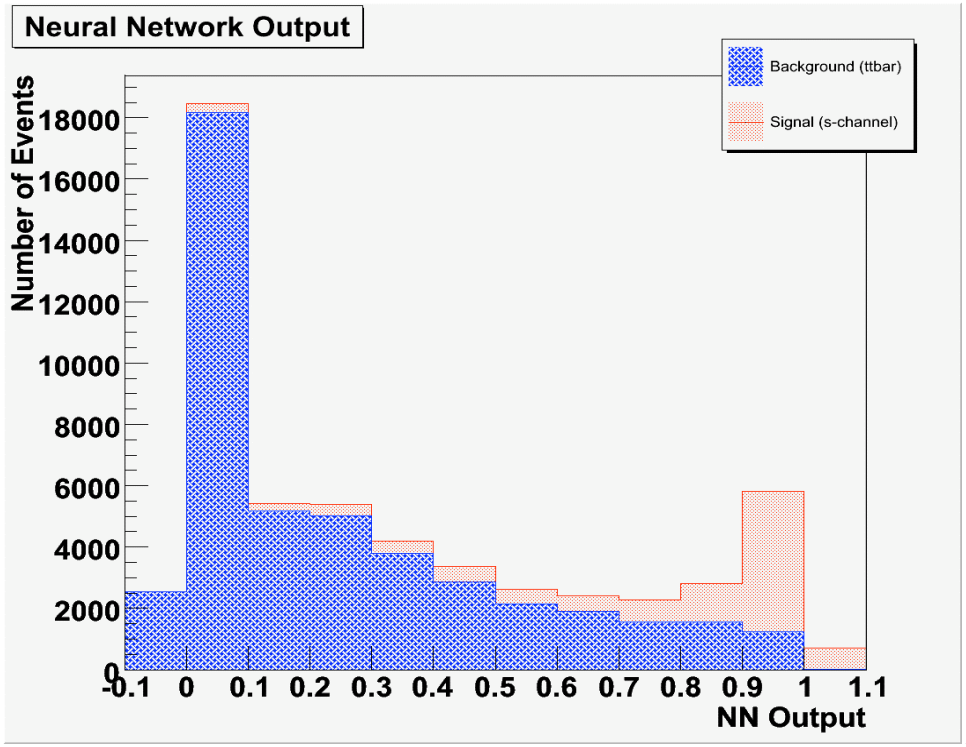
Systematics in progress

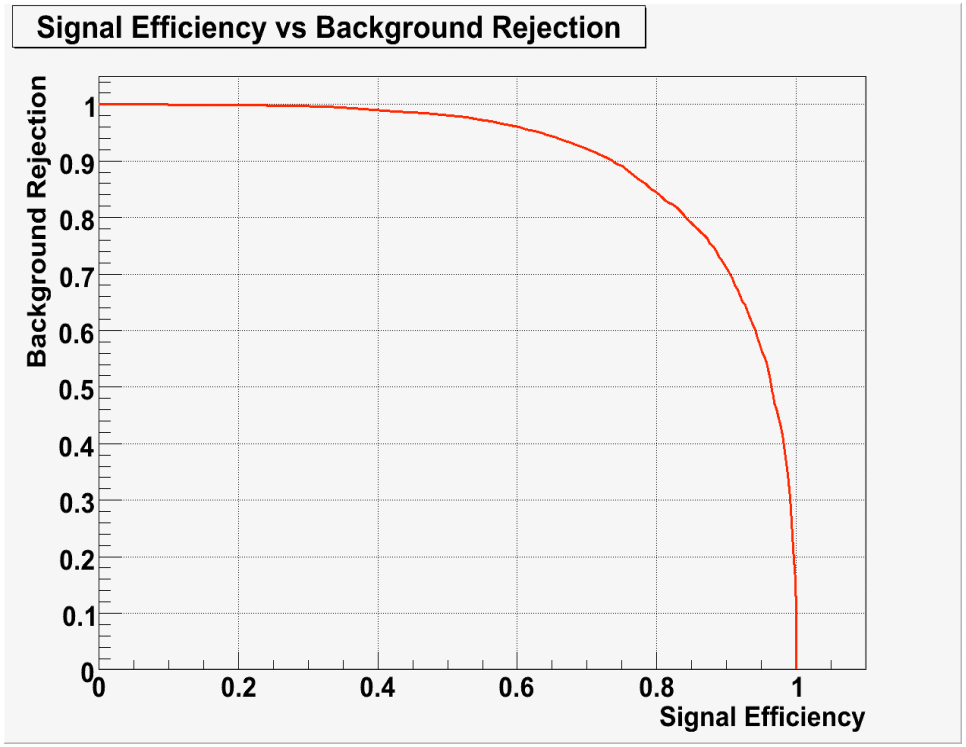
- Tests NN results with AlpGen ttb, W+jets, Wt

Neural Network t-channel analysis

Nathan Triplett
Iowa State University

- Example NN output for t-channel vs ttbar background shown below
  - The same techniques will be used for the other backgrounds





Conclusions

MC production

All top samples available fullsim/FastSim

W+jets/Wbb+jets available in FastSim only

MC Validation

→ Validation of AcerMC with NLO for the t-channel

Plan to have MC@NLO samples

RecoPerformance

→ huge progress in lepton, mET and jet (fullSim vs FastSim)

→ Contacts with and feedback to RecoPerf group

TRF Tag

Implementation OK & used in some analyses

Single-top Analyses

Wt and s-channel should be completed soon

ISR/FSR systematic studies started